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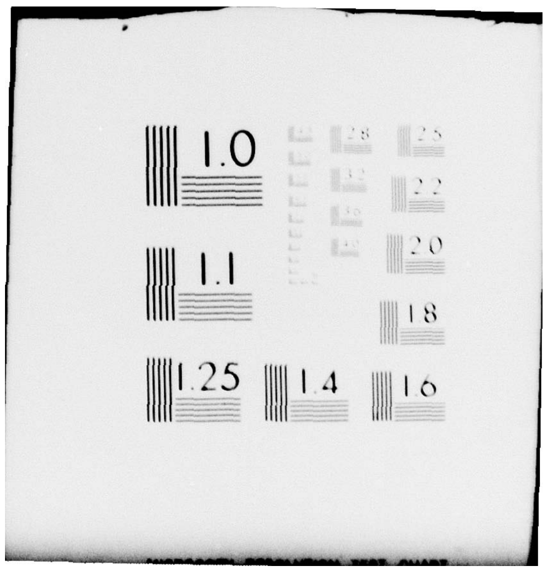
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DEPARTMENT OF DEFENCE

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MELBOURNE, VICTORIA

REPORT

MRL-R-753

CORROSION IN THE AUSTRALIAN DEFENCE SCENE

2. THE NAVY

Jeffrey J. Batten

Approved for Public Release

AUGUST, 1979

DEPARTMENT OF DEFENCE

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ABSTRACT

This report concludes that most of the corrosion problems experienced by the steel components of a ship may be attributed to design shortcomings. These problems have arisen because satisfactory protective coatings could not be applied over inadequately prepared surfaces due to their lack of accessibility. Corrosion problems involving metals other than steel are also attributed to design faults. Thus most of the corrosion problems encountered result from a lack of application of existing technology.

Research of a basic nature is still needed in areas such as hot corrosion in gas turbines, inhibitors for cooling systems, coatings for magazine decks, and materials for sea water systems.

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16. ABSTRACT (if this is security classified, the announcement of this report will be similarly classified):

This report concludes that most of the corrosion problems experienced by the steel components of a ship may be attributed to design shortcomings. These problems have arisen because satisfactory protective coatings could not be applied over inadequately prepared surfaces due to their lack of accessibility. Corrosion problems involving metals other than steel are also attributed to design faults. Thus most of the corrosion problems encountered result from a lack of application of existing technology.

Research of a basic nature is still needed in areas such as hot corrosion in gas turbines, inhibitors for cooling systems, coatings for magazine decks, and materials for sea water systems.

SUMMARY

From a review of the corrosion problems experienced in both surface ships and submarines it is concluded that most of the corrosion problems experienced by the steel components of a ship in areas such as the hull, ballast tanks, and machinery spaces may be attributed to design shortcomings. In general, these problems have arisen because satisfactory protective coatings could not be applied over inadequately prepared surfaces due to the lack of accessibility of the particular areas. Corrosion problems involving metals other than steel are also attributed to design faults.

Thus most of the corrosion problems encountered do not result through inadequate existing technology but from a lack of application of that technology.

Corrosion research of a basic nature is still needed to reach a practical solution in areas such as hot corrosion in gas turbines, inhibitors for cooling systems, coatings for magazine decks, and materials for sea water systems.

The paper was presented at a meeting of TTCP-P-TP1 in New Zealand in May 1979 as part of the Australian contribution to Assignment Number 6 : "Corrosion Detection, Monitoring and Assessment".

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(Continued)

CORROSION IN THE AUSTRALIAN DEFENCE SCENE

2. THE NAVY

1. INTRODUCTION

Corrosion problems experienced by the Army and the Air Force were discussed in a previous report [1]. Corrosion problems in the Navy are distinguished from those of the other Services because Navy corrosion problems are much more severe due to the extreme aggressiveness of the marine environment experienced by Navy equipment. No other natural environment could be more harmful to the steel of a ship than salt water, especially in the warmer climates.

Consider a surface ship; externally the hull has to be able to withstand either complete immersion in salt water or frequent splashing by it, while the external surfaces of the superstructure are continually coated with salt crystals. Internally, high humidity air is drawn into the ship for ventilation, bringing with it salty dampness. Thus steel surfaces, such as decks under vinyl tiles, are exposed to this marine environment. Further, inaccessible areas are exposed to this environment; these areas include the internal surfaces of the hull and machinery spaces (inaccessible spaces under the machinery footings and boiler mountings). Wet spaces have their own specific problems; these areas include bathrooms, laundries and tanks filled with diesel fuel, salt water (for ballast), or fresh water.

Steel is at present the most cost-effective material which can be considered as a major constructional material for larger ships, hence for its survival it requires to be protected from this environment. Because the marine environment rapidly corrodes bare steel, the most practical and realistic method of preventing this steel from corroding is by the use of suitable coatings that separate the steel from the corrosive environment.

This paper summarises corrosion problems in the Australian Navy as experienced by staff of Electrochemistry Group, Materials Research Laboratories (MRL), either by direct association with the problem or through participation in the Royal Australian Navy Corrosion Committee (RANCC). The paper was presented to TTCP Sub-Group P, Technical Panel P1 (Metals) at a meeting in New Zealand in May 1979. It formed part of the Australian contribution to Assignment Number 6, "Corrosion Detection, Monitoring and Assessment".

2. CORROSION PROBLEMS IN SURFACE SHIPS

2.1 External Areas of the Hull

Because of recent improvements in the external hull coatings of warships, anti-fouling and protective films now have a reasonable life thus permitting docking intervals to be extended. Thus by the careful use of these protective films, together with the use of cathodic protection, the areas of the hull below waterline do not pose major corrosion problems.

This is not the case, however, in the wind and waterline area. This area is not protected by the cathodic protection system on a ship and, because the protective paint coat is often damaged or removed by mechanical abrasion during docking, corrosion of the underlying steel hull does take place.

The present solution to this problem is to use an epoxy zinc-rich primer; this is a tougher paint system hence will resist mechanical damage, and because of the presence of the zinc will provide some galvanic protection to abraded areas.

2.2 External Superstructure

The main corrosion problems in this area are associated with radar and radio antennae. These are constructed of a high strength aluminium-copper alloy, and being exposed to hot sooty funnel gases containing acidic combustion products, rain and salt water spray, this alloy is in a particularly aggressive environment.

Trials are being conducted to compare various paint systems over "Alclad" (a coating of pure aluminium over the above alloy).

2.3 Internal Corrosion of Hull Plating

The River Class destroyer escorts of the RAN were designed for a hull life of 15 years. At present some have been in service for 19 years and it is intended that they continue in service for another 10 years after modernisation [2]. This hull life is determined by dimensioning the strength of plate and frame required to withstand the rigors of the sea and the rigors of war, and then adding an allowance for the corrosion expected over the design life.

The above corrosion is predominantly that taking place from the inside outwards. This corrosion is extremely hard to control because the inside of a ship is a maze of bulkheads, longitudinals, pipelines, cable-trays, frames, tanks, and these create many small inaccessible areas. Corrosion in these areas results from inadequate surface preservation as a result of inaccessibility.

Where the above corrosion is sufficiently bad (i.e. the strength of the plate has been weakened) then it is necessary to remove these plates and weld in new ones. In a recent example it was estimated [3] that the cost of repairs to the machinery space hull plating alone during HMAS PARRAMATTA's current modernisation was in excess of $100 000.

Since the primary cause of many of the problems created by inboard corrosion are due to difficulty associated with the application and maintenance of protective coatings, usually because of lack of accessibility, it is suggested that by more careful attention at the design stage, adequate accessibility might be achieved.

It is contended that the first line of defence against hull and structural corrosion is insistence on good design to ensure that corrosion-prone areas are not built into the structure. Good design should :

(a) Minimize water-retaining areas, thus the aim should be to provide maximum drainage, and

(b) provide at least reasonable access for surface preparation and coating, and facilitate coating maintenance.

Thus good design concepts should result in :

(a) Lower corrosion intensity and less localisation of corrosion,

(b) more satisfactory initial preparation and application of coatings, and

(c) less, and more satisfactory, maintenance of coatings already in service.

In practice the performance of protective coatings is frequently determined not by the intrinsic properties of the coating itself but by the practical inadequacies in :

(a) Surface preparation of the base metal,

(b) coating application and maintenance, and

(c) the local intensification of corrosion factors due to bad design.

Because of the above, it should be mandatory that anticorrosion structural design be given very early priority in the ship design schedule. In the practical situation, however, it is realised that most of the RAN acquisitions are of overseas design and construction, and therefore for a new ship the RAN has little control over factors affecting corrosion in the design and construction phases. *This is not the case, however, for a refit, modernisation or conversion of all types of naval ships and it is to these situations that this paper is primarily addressed.*

Concerning corrosion in machinery and ancillary equipment, the purchase of much commercial equipment precludes significant design control. Such problems, therefore, have to be treated on their merits. Corrosion prevention methods such as material selection, environmental control, inhibition, and operational control may be applicable in these cases.

2.4 Corrosion Under Deck Tiles

The principal cause of this corrosion has been the presence of water from repeated sluicings (even with fresh water) and ingress of salt and moisture. This moisture has reached the steel deck through cracks between the tiles or through cracks where the tiles abut bulk heads and fittings. Massive corrosion damage has resulted, and this has necessitated the replacement of extensive deck areas. Trials are being conducted by the RAN to determine the best means of coping with this problem.

2.5 Corrosion in Machinery Spaces

During construction, areas under pedestals must be coated after all fabrication (welding) is completed. Design (lack of accessibility) often prevents this being done satisfactorily. Further, maintenance of these protective coatings is difficult not only because they are in awkward inaccessible places, but also because they are often located in a hot and difficult working environment. However, structural integrity is important and inaccessible areas such as these have to be surveyed at frequent intervals, and corrosion damage rectified where possible. Typical of these areas are machinery footings and boiler mountings.

During a refit when machinery is lifted it is most essential that these inaccessible spaces be cleaned, zinc or aluminium sprayed, and then well coated.

2.6 Corrosion of Vent Trunking and Cable Trays

Accessibility to the air ducts for corrosion-maintenance purposes is normally very difficult because they are quite often located beneath fittings. Similarly, there are difficulties of cleaning and painting behind cable trays.

Again these arose through a design problem, and this problem is not easy to resolve while the procurement of ships is from other countries.

2.7 Corrosion in Wet Spaces

Corrosion problems are encountered in bathrooms, galleys, and laundries. One means of reducing these corrosion problems is to install better ventilation and metal spray to full height. It has also been suggested that stainless steel inserts be fitted in deck areas. This is a continuing problem.

2.8 Corrosion within Fuel Tanks

Corrosion problems have been experienced inside fuel oil tanks in DDG's. Normally it might be expected that the oily environment would protect the steel surface, however the salt-laden air above the fuel oil surface (probably abetted by condensed water vapour and sulphur from the fuel oil) attacked the steel surface of the tank.

The main problem with the preservation of tanks for diesel oil (DIESO) and aviation fuel (AVCAT), is the high cost of achieving a good tank coating, where the main cost is in the initial surface preparation. However, such a

coating can be effective in preventing corrosion, and in the end the cost would be less than the cleaning back, making good, and recoating of inadequately preserved surfaces.

2.9 Corrosion within Ballast Tanks

Lack of accessibility to the internal surfaces of these tanks hinders both the preparation of surfaces of adequate quality and the successful application of protective coatings. At present an investigation is being conducted on the use of self-gelling oil as a protection coating for seawater ballast tanks.

2.10 Preservation of the Decks of Magazines and Associated Areas

Because 4.5 inch shells and 40 mm aircraft ammunition are susceptible to electrostatic charges or stray radio frequency, areas where they are likely to be located must have conducting floors. For this reason these areas cannot be coated with conventional paints. In some of these areas the deck plating can be metal sprayed, however if this is impracticable the deck plating is left as bare metal - thus is readily available for corrosion processes to occur. A suitable surface protective coating in these areas is required.

2.11 Boiler Corrosion

Internal corrosion has been experienced in the boilers of the DDG HMAS BRISBANE, and this has been attributed to insufficient control of boiler water pH and the possibility that the concentration of dissolved oxygen is too high. To these ends morpholine may be used to control the pH and hydrazine may be used as an oxygen scavenger.

2.12 Corrosion of Evaporator Shells

Corrosion damage has been detected in the evaporator shells of HMAS PARRAMATTA, HMAS STUART and HMAS DERWENT (all destroyer escorts). It was recommended that in future these should be made from 90/10 copper nickel. Scale control in these distilling plants is controlled by "Ameroyal" (predominantly poly(acrylic acid) in an alkaline solution containing a surface-active agent).

2.13 Corrosion in Diesel Engine Cooling Systems

Because this is a recurrent problem, a Working Party has been established to investigate inhibitors for use in diesel engine cooling systems. The object of the Working Party is to recommend a universal, safe, simple, satisfactory, and cost-effective inhibitor.

Previously sodium chromate had been used as a corrosion inhibitor in diesel engines, however because of its toxic properties it is no longer used in these engines connected to waste heat distilling plants.

The requirement is now urgent as the Attack Class and the Fremantle Class Patrol Boats, and the FFG's, are all to be fitted with waste heat fresh water generators (evaporators).

2.14 Corrosion Problems in Sea Water Systems

Because this is a recurrent corrosion problem area the SWS Working Party is to be re-convened. Its first task will be the investigation of replacements for the Carver Pumps on the DDG's and the Worthington-Simpson Pumps on the Type 12 DE's.

3. CORROSION PROBLEMS IN SUBMARINES

As submarines undergo regular and extensive refits about every four years, and in these the boat is virtually gutted, anti-corrosion treatments can be applied to all the normally inaccessible areas within the hull at more frequent intervals than can be done with surface ships. Nevertheless, because of the high humidity and high salt content of the internal air, persistent efforts are necessary on corrosion prevention measures between refits. Basically, however, the requirements of submarines and surface ships are similar.

The exterior hull is sandblasted and re-coated during each refit, but corrosion problems do persist in the wind and water area. The main exterior hull corrosion problem, however, is near the exhaust outlets (mufflers). Because this area of the hull is heated by the exhaust system it is difficult to maintain a protective paint film on it. Also, this area is in the splash zone when the submarine is on the surface and hence it is not protected by the cathodic protection system of the submarine.

A trial is being conducted on HMAS OXLEY with this area protected with three coats of a coal tar epoxy. Another suggestion is to use an aluminium spray. The investigation is continuing.

Internally, submarines have two particularly troublesome areas, namely propeller shafts and muffler tanks. To the former end, a submarine tailshaft corrosion Working Party was established. This Working Party recommended that nickel alloy cladding be carried out on the whole area of the shaft between the stern gland seal and stern gland tube bearings. HMAS OXLEY will be the first submarine to be so fitted.

With regard to the submarine exhaust muffler tanks, new design steel tanks are being tested and are performing well. An Incoloy tank has also been tested, and although its performance was excellent, it may not be the most cost-effective solution. Further, it could cause galvanic corrosion of the hull plate in contact with it.

4. CORROSION PROBLEMS IN NAVAL WORK BOATS

4.1 33 ft G.R.P. Craft

This problem was concerned with the extremely rapid and severe "cutting out" of the nickel/aluminium/bronze propellers. Because of its magnitude this was considered a major problem.

The subsequent investigation concluded that the pattern of damage was characteristic of that arising from cavitation erosion, that both the material of construction and casting technique were satisfactory, and that the problem arose because the clearance of the propeller tips and hull was too small and that the speed of the tips was too high.

It was recommended that cathodic protection be applied to the propeller (this could work where the cavitation level was not too severe). However, if propeller protection was not afforded by cathodic protection, then it could only be concluded that cavitation was of such a high intensity as to require a redesign of the hull-shaft-propeller geometry as the only alternative approach.

In terms of the classification of problems outlined in the previous paper [1] (reproduced in Appendix 1), this problem would be classified as A3, i.e. adequate technology but technology transfer to the designer inadequate.

4.2 12 m Aluminium-Alloy Naval Work Boats

This problem was concerned with the very rapid corrosion (rusting) of the stainless steel propellers of these workboats. The failure was mainly attributed to the choice of the alloy. Type 410 cast "stainless steel", as originally specified for the propellers, does not have sufficient inherent resistance to corrosion by sea water for the intended application. This is due to too low a chromium content, and it has the lowest general corrosion resistance of any of the "stainless" iron/chromium alloys.

An alternative alloy CA-15 was also used, and again failure occurred after about two months. As this alloy is identical with Type 410, the result is not surprising.

The minimum quality of stainless steel likely to give satisfactory long term service in sea water would be the austenitic 18/8/Mo Type 316 alloy. On strength considerations the casting alloy ASTM A296 CD 4M Cu would be acceptable, and because of its high chromium content (24.5 to 26.5% Cr) and molybdenum content it would be expected to have a corrosion resistance in sea water at least as good as Type 316. Therefore it would be an acceptable alternative. Good foundry practice would be required to ensure the low carbon content specified (0.04%).

Also associated with these workboats is a potential problem due to corrosion of the Y-brackets. These are of cast aluminium alloy LM10 (Al + 10% Mg), an alloy known to be susceptible to intergranular corrosion and stress corrosion cracking, especially in corrosive environments such as sea water. It was recommended that this alloy not be used in an important component such as a Y-bracket, especially as alternative non-susceptible alloys are available.

In the terminology of the previous paper [1], this problem would fall into category A3 (see Appendix 1).

5. GAS TURBINES

It is quite well known that the hot end of gas turbines are particularly susceptible to corrosion, the rate of which is accelerated by the salt-laden marine environment. Thus problems would be anticipated with the LM 2500 engine being fitted in the FFG's for the RAN. For example, the first stage blading of LM 2500 turbines fitted in commercial aircraft last 6000 hours, whereas the blades in the marine version last only 3000 hours.

Similarly high-temperature corrosion problems are experienced in the gas-turbine engines of the RAN Westland Sea King helicopters.

Research in this field of "hot corrosion" is very active, and MRL is contributing some of its expertise to help solve the problems in this area.

6. NAVY MUNITIONS

6.1 *Ikara Missile: Telesender Voltabloc Batteries*

Major corrosion damage was detected in these nickel-cadmium batteries in store. It is thought that about 300 of these batteries were affected, each costing about $100. Corrosion damage was attributed to leakage of alkaline electrolyte from inadequately sealed batteries. Incorrect design was blamed for the damage.

This failure would fall into category A1 of Appendix 1.

6.2 *Bofors Mk 7 40/60 Mountings*

Corrosion has been observed in these mountings and corrosion preventive treatments recommended. It was suggested that the components should be hot dip galvanised or sprayed with an aluminium metal coating as this would have significantly better corrosion resistance than an equal thickness of zinc in marine atmospheres and high humidity environments. Additional protection by the application of organic coatings was recommended also.

7. SUMMARY OF CORROSION PREVENTION MEASURES

7.1 *By Good Design*

If it is accepted that many of the internal corrosion problems of a ship arise because protective coatings cannot be adequately applied due to lack of accessibility, then it will be appreciated that the design phase in the life of a ship is of paramount importance in the fight against corrosion. It is at this stage that materials are selected, maintenance accessibility is determined and preservation schemes are specified.

Unfortunately the RAN has, or has had, little control over the design of its major ship acquisitions, for all are of overseas design using

conventional displacement hulls constructed from conventional structural steels. Thus the RAN has little control over factors affecting corrosion in the design and construction phases of a new ship.

However, this is not the case for a refit, modernisation or conversion, and here we should not repeat past errors. The expertise available within MRL could assist the RAN in overcoming many of their corrosion problems.

7.2 *By the Use of the Correct Materials*

Although this is part of "Good Design" its importance warrants greater attention, particularly when the aggressive nature of the marine environment is taken into consideration. Metals for components such as propellers, piping and valves in sea water systems cannot be protected from the aggressive environment by organic coatings and are, therefore, in direct contact with sea water. Accordingly these metals must be chosen carefully.

It is also important to ensure that galvanic corrosion is prevented. Thus, for example, an aluminium bronze propeller will become badly pitted if used on a Monel propeller shaft in sea water.

7.3 *By Organic Coatings*

The corrosion of steel is typically prevented by the application of protective organic coatings, and for this the importance of adequate surface preparation cannot be over-emphasised. The main problem is the difficulty of achieving the high standard of surface preparation required in areas where accessibility is difficult. Because the outside of a ship is reasonably smooth and accessible (at least from the waterline upwards), the main problem areas are inside the hull.

The main advancement in this area would arise from the development of a good protective, long-life paint system that could be satisfactorily applied over areas where it is not possible to achieve a high quality in the surface preparation.

7.4 *By Inorganic Coatings*

The use of metallic coatings for the protection of other metals from corrosion is based on the fundamental principle that a metal will not corrode unless it is in contact with the corrosive environment. Thus, any form of continuous barrier which is interposed between the metal surface and the corrodent will have anti-corrosive properties even if the corrosion is only transferred from the massive constructional metal to the thin covering of the protective coating. Metallic coats may be applied as coats alone or in conjunction with paint coats.

A number of factors needs to be considered in the selection of the best protective metallic coating. For example, the coating must resist the environment to a greater degree than does the basis metal, it must in no way encourage local corrosion of the underlying material - in some cases (e.g. zinc or iron) it may also confer cathodic protection on it, it needs the elasticity, hardness and wearing qualities suitable for the operational requirements, and it should be as free from pores as possible.

Zinc, cadmium, and aluminium coats may be used for the protection of areas such as structural steel components, deck areas, machinery equipment, navigation systems, ship pipelines, and electric systems. The choice of coating and the method of application depends on sizes, shapes and material of the structure to be protected, corrosion influences, and other technical-economic reasons. The methods of application include hot-dipping, electrolytic methods, metal spraying and cladding.

7.5 *By Cathodic Protection*

Protection of the external metal surfaces (hull, rudder, propellers) by cathodic protection (C.P.) works extremely well in areas continuously immersed in the sea. Nevertheless there are still problems that require elucidation. For example, we have found some anodes used for the C.P. of ships to be passive, while others which were nominally identical in all ways were effective in affording protection.

7.6 *The Role of Management*

Many corrosion defects can be traced back to management decisions. For example, financial restraints dictated a reduction in the preservation treatment for the oceanographic ship HMAS COOK, and it is estimated [3] that this may reduce the ship's life by five years.

The role of management in corrosion control is of prime importance. Management has the final responsibility for decisions concerning the application of adequate anti-corrosion measures. Therefore management must be convinced of the long term economic advantages of these approaches.

8. CORROSION MONITORING

Corrosion monitoring in Naval ships, particularly in sea water systems, is a technique with a considerable amount of potential. There are, however, two main problems associated with this technique. These are, firstly, the need to identify the specific areas where it is necessary to monitor the corrosion, and secondly, the need to devise a method of measuring (and interpreting the measurement of) the corrosion in the closely defined localised area.

The state-of-the-art of corrosion monitoring is such that there is need to improve techniques for detecting the onset of corrosion and for measuring its subsequent growth.

The purpose of our study is to examine available techniques, and devise feasible new automated techniques, to enable efficient monitoring of the more costly types of corrosion damage in Naval ships, or of corrosion in critical areas where rapid and/or catastrophic failure could occur. Of particular interest are the areas where the failure would be unpredictable from available design data.

In Electrochemistry Group, Metallurgy Division, MRL, considerable progress has been made towards the development of an automated corrosion monitoring system.

REFERENCES

1. Batten, J.J. (1979). Corrosion in the Australian Defence Scene. 1. The Army and Ancillary Equipment for the RAAF. Report MRL-R-752.

2. Reed, M.P. (1977). Corrosion Prevention is Everybody's Business. Fleet Maintenance Bulletin, November.

3. Dechaineux, P.G.V. and Mulligan, M. (1978). Corrosion - Our Continuing Common Enemy. Lecture presented at the Engineer Officers' Symposium at Nirimba, December.

APPENDIX 1

CLASSIFICATION OF CORROSION PROBLEMS ACCORDING TO TECHNOLOGY AND ITS TRANSFER, AND USAGE HISTORY

Usage History or Intended Usage of Equipment	Adequate Technology		Inadequate Technology (C)
	Technology transfer inadequate to the designer and/or to the manufacturer (A)	Technology transfer inadequate to the user (B)	
In Long Term Storage (1)	(A1)	(B1)	(C1)
Seldom Used (2)	(A2)	(B2)	(C2)
Frequently Used (3)	(A3)	(B3)	(C3)

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